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THESIS

INTEGRATED SERVICES DIGITAL NETWORK (ISDN)

by

Margaretmary Torelli Weidert

June, 1985

Thesis Advisor: C. R. Jones

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This thesis contains development of a conceptual framework for an Integrated Services Digital Network (ISDN) and relates ISDN concepts to non-tactical Department of Defense (DoD) communications applications. The conceptual framework developed is non-technical and is intended to provide general management with an introduction to the ISDN. An existing model communications system, Japan's Information Network System (INS), which exhibits characteristics of ISDN, is also discussed in

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Integrated Services Digital Network (ISDN)

by

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Lieutenant Commander, United States Navy
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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

This thesis contains development of a conceptual framework for an Integrated Services Digital Network (ISDN) and relates ISDN concepts to non-tactical Department of Defense (DoD) communications applications. The conceptual framework developed is non-technical and is intended to provide general management with an introduction to the ISDN. An existing model communications system, Japan's Information Network System (INS), which exhibits characteristics of ISDN, is also discussed in terms of the conceptual framework developed. General ISDN concepts are also related to DoD applications. The Defense Data Network (DDN) is presented as a candidate network on which a potential military ISDN could be based.

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LIST OF ACRONYMS AND ABBREVIATIONS

ARPANET	Advanced Research Projects Agency Network
AT&T	American Telephone and Telegraph
AUTODIN	Automatic Digital Network
AUTOVON	Automated Voice Network
CBX	Computerized Branch Exchange
CCITT	International Telephone and Telegraph Consultative Committee
CPE	Customer Premises Equipment
DDN	Defense Data Network
DoD	Department of Defense
FCC	Federal Communications Commission
FDM	Frequency Division Multiplexing
IDN	Integrated Digital Network
INS	Information Network System
ITU	International Telecommunications Union
NCTE	Network Channel Terminating Equipment
NTT	Nippon Telegraph and Telephone Corporation
OSI	Open Systems Interconnection
PCM	Pulse Code Modulation
POM	Program Objective Memorandum
POTS	Plain Old Telephone Service
TDM	Time Division Multiplexing

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I. INTRODUCTION

A. PURPOSE

The purpose of this thesis is to develop a conceptual framework for an Integrated Services Digital Network (ISDN) and relate ISDN concepts to non-tactical Department of Defense (DoD) communications applications. The framework developed will be non-technical and is intended for use by general management as an introduction to the ISDN.

B. BACKGROUND

The International Telegraph and Telephone Consultative Committee (CCITT) of the United Nations' International Telecommunication Union (ITU) defines ISDN as:

> "A network evolved from the telephone network that provides end-to-end digital connectivity to support a wide range of services, including voice and non-voice services to which users have access by a limited set of standard multipurpose customer interfaces." [Ref. 1: p. 27]

Non-voice services include the broad categories of data, text, and imagery. [Ref. 2: p. 79] The National Telecommunications and Information Administration (NTIA) parallels the ISDN to "a shopping center of tomorrow... [whose] success...is based on...the desires of people to have a sole supplier for their services." [Ref. 3: p. 95]

Recent American Telephone and Telegraph (AT&T) marketing literature has stated that, with ISDN, users will be able to

access a network as easily as using "today's modular phone jack and [ISDN will be] as compatible with different equipment designs as an ordinary electrical outlet." [Ref. 4: p. 60]

The ISDN is a concept evolving out of current telephone technology [Ref. 5: p. 12] and it is estimated that one to two decades will be required to complete the transition. [Ref. 6: p. 8] This evolution is expected to occur as a natural extension of the digital transmission and switching technologies of telephone Integrated Digital Networks (IDN's). [Ref 5: p. 12] As early as 1981, ISDN was considered to be

> "...the ultimate goal of present telecommunications network evolution, combining voice and a wide range of non-voice services on a common network utilizing digital transmission and switching. Digital exchanges...will ensure a smooth transition from the present analog network, through the integrated digital network, to a future ISDN." [Ref. 7: p. 2]

C. METHODOLOGY

To develop the ISDN conceptual framework, a search of the current literature including periodicals, technical journals, and technical books, was conducted. Pre-ISDN systems were studied to trace the evolution toward ISDN along with a review of the technologies influencing the evolution toward ISDN.

Model integrated digital networks exhibiting ISDN characteristics were investigated to understand existing system configurations. Interviews were conducted at

National Communications System offices in Arlington, Virginia.

D. SCOPE

The emphasis of the thesis will be to develop a non-technical conceptual framework for the ISDN. Relevant technologies in the development of ISDN will be discussed to the degree necessary for background information.

The thesis will not make specific ISDN recommendations for the DoD. It will, however, present ISDN concepts for consideration in non-tactical DoD applications.

E. THESIS ORGANIZATION

Chapter I provides an introduction to the thesis. It describes the purpose, background, methodology, and scope of the thesis.

Chapters II through VI give background and develop the conceptual framework for ISDN. Chapter II provides background material on technologies leading to the ISDN; concepts and objectives are presented and some political and technological issues discussed. Chapter III contains a description of the emerging technologies which make ISDN feasible for multipurpose communications. Chapter IV contains a discussion of the relationships of the telecommunications carriers, equipment suppliers, and users of the ISDN. Chapter V contains a discussion of the

features of ISDN, as applied to the conceptual framework developed.

Chapter VI contains a description of an experimental network with characteristics of an ISDN. Chapter VII contains a description of the ISDN concepts which may be applicable to non-tactical DoD communications.

Chapter VIII contains a discussion of some issues which must be resolved before global ISDN's can exist. It also contains a summary of the evolution toward ISDN. Existing IDN features which will facilitate the gradual transition from IDN to ISDN are discussed. Potential DoD applications are also summarized.

II EVOLUTION TOWARD AN ISDN

A. BACKGROUND

"Historically, analog transmission has dominated the telecommunications industry since its inception." [Ref. 8: p. 104] Analog, or continuous, signals typically transmit voice while digital, or discrete, signals are required for most data communication. [Ref. 9: p. 18] The transmission of an analog signal requires amplification because the signal weakens with distance. Any noise that accompanies the signal is also amplified. Digital signals, however, are repeated periodically during transmission and data integrity is maintained. For transmitting data in its binary format, digital systems usually exhibit lower error rates than analog systems because of the periodic signal regeneration during transmission. [Ref. 8: p. 104]

Other advantages of digital transmission are that a variety of services, such as voice, data, and facsimile, can be multiplexed for more efficient equipment usage; much higher data rates utilizing existing lines are also possible. "As the cost of digital computers and integrated circuit chips continues to drop, digital transmission and its associated switching is likely to become much cheaper than analog transmission as well." [Ref. 8: p. 105]

The idea of an integrated digital network (IDN), where digital transmission and switching functions are integrated, was proposed by Vaughan of the Bell System in 1959 and "is in the process of being implemented worldwide." [Ref. 10: p. 538] The IDN will

> "combine the coverage of the geographically extensive telephone network with the data carrying capacity of digital data networks in a structure called ISDN where 'integrated' in ISDN (as differentiated from IDN) refers to the simultaneous carrying of digitized voice and a variety of data traffic on the same digital transmission links and by the same digital exchanges. The key to ISDN is the small marginal cost for offering data services on the digital telephone network, with virtually no cost or performance penalty for voice services already carried on the IDN." [Ref. 7: p. 2]

The ISDN is expected to be the next step in the evolution beyond IDN. As stated by Kostas, [Ref. 5: p. 12]

> "ISDN's will be based on the concepts developed for telephone Integrated Digital Networks (IDN's), and may evolve by progressively incorporating additional functions and network features, including those of other dedicated networks such as circuit-switching and packet-switching for data, so as to provide for existing new services."

B. KEY OBJECTIVES AND ATTRIBUTES OF ISDN

The development of a worldwide ISDN has involved the efforts of many national governments, standards organizations, and equipment manufacturing companies. Certain common objectives of an ISDN are shared by the various groups and these key objectives are listed by Stallings [Ref. 10: p. 540] as:

> "Standardization: It is essential that a single set of ISDN standards be provided to permit universal access and to permit the development of cost-effective equipment.

Transparency: The most important service to be provided is a transparent transmission service. This permits users to develop applications and protocols with the confidence that they will not be affected by the underlying ISDN.

Separation of competitive functions: It must be possible to separate out functions that could be provided competitively as opposed to those that are fundamentally part of the ISDN. In most countries, a single, government-owned entity will provide all services. Some countries desire (in the case of the United States, require) that certain enhanced services be offered competitively (e.g., videotex, electronic mail)....

Leased and switched services: The ISDN should provide dedicated point-to-point services as well as switched services. This will allow the user to optimize his or her implementation of switching and routing techniques.

Cost-related tariffs: The price for ISDN service should be related to cost, and independent of the type of data being carried. One type of service should not be in the position of subsidizing others.

Smooth migration: The conversion to ISDN will be gradual, and the evolving network must coexist with existing equipment and services. Thus ISDN interfaces should evolve from current interfaces, and provide a migration path for users.

Multiplexed support: In addition to providing low-capacity support to individual users, multiplexed support must be provided to accommodate user-owned CBX [computerized branch exchange] and local network equipment."

While the objectives stated above should not be considered as an all-inclusive list, they represent the major considerations which are forming the development of the ISDN.

The CCITT, which serves as the controlling body for ISDN standards, defines the ISDN through the following six attributes: [Ref. 10: p. 535]

"1. The ISDN is to evolve from the existing telephone networks, which themselves are evolving into integrated digital networks.

2. New services introduced into the ISDN should be compatible with the basic 64 Kbps switched digital connections.

3. The ISDN will require from 10 to 20 years (from the early 1980's) for full transition.

4. During the transition, the ISDN will rely on internetworking among the national ISDN's and other non-ISDN networks (such as public data networks).

5. The ISDN will contain intelligence for the provision of service features, maintenance and system control, and network management.

6. The ISDN will use a layered functional set of integrated protocols for the various access arrangements."

These six attributes are guiding the development of standards related to signaling, network interfaces, and protocols. [Ref. 10: p. 545]

C. CCITT INVOLVEMENT IN ISDN

The CCITT is one of seven organs of the International Telecommunications Union, an agency of the United Nations. The CCITT

"attempts to promote and ensure the operation of international telecommunications systems...by issuing Recommendations (or standards) for end-to-end performance, interconnection, and maintenance of the world networks for telephone, telegraph, and data communication." [Ref. 9: p. 67]

Fifteen study groups review the recommendations over a designated three year period. The recommendation cycle is described in detail in NTIA Report 83-138. [Ref. 9: App. A]

The Digital Networks study group (SG), SG XVIII, is the "principal coordinating body for CCITT ISDN standards activities." [Ref. 10: p. 547] Key areas addressed by other study groups which influence SG XVIII are telephone operation and quality of service (SG II), transmission maintenance (SG IV), data communication networks (SG VII), telephone switching and signaling (SG XI), and data communication over the telephone network (SG XVII).

In this country, the United States CCITT Organization is "advisory to and under the jurisdiction of the Department of State." [Ref. 9: p. 70] The U.S. CCITT channels U.S. interaction with the international CCITT and has four main functions: to offer a forum for the telecommunications industry for "participation in the standards-making process;" to serve as an "arena for discussion and debate" prior to "development of U.S. positions and contributions;" to provide "guidance for delegates at the international meetings;" and to serve as a "pool" of representatives from the private sector who can be selected for the U.S. delegation staff. The U.S. CCITT admits members from "industry, government agencies, scientific organizations, user groups, and standards groups." [Ref. 9: p. 71]

D. POLITICAL AND TECHNICAL ISSUES

There are many issues associated with the evolution toward ISDN. The issues may be categorized as international

and national with policy-oriented (political) and technical issues in each category. [Ref. 9: p. 52]

International policy issues arise from the "desire for national sovereignty." They include national security and survivability, privacy and industrial development, foreign competition and market protection in international trade, standards which do not conflict with national policy, protection of cultural identity and sovereignty, and fair and equitable regulation of routing and tariffs. [Ref. 9: p. 52]

On the international scale, technical issues arise from the "need for universal, affordable services." Interfacing the various national networks, necessity of a common scheme for addressing, effect of signaling and digitization on defense posture, general standards development, and perceived quality of service are the primary issues under discussion. [Ref. 9: p. 52]

There are some national issues which are unique to the pro-competitive nature of business in the United States. Competition and deregulation in industry serve to induce profit and expand the marketplace. These issues include ownership and control of telecommunications functions, network or terminal location of certain intelligence functions, impact of new technologies, interconnection of multiple networks in an ISDN structure, the distinction

between basic and enhanced services, and the type of user access. [Ref. 9: p. 53]

A diversity of new technologies is created in a competitive market environment. Technical issues are interconnection among multiple ISDN's, traffic distribution over specialized networks, performance and quality of service ratings, treatment of technological advances, and user access and management. [Ref. 9: p. 54]

E. SUMMARY

A discussion of the relative performance characteristics of analog and digital systems was presented as background for the evolution toward IDN's. ISDN is the 'ultimate goal' of the present telecommunication network evolution. Objectives and attributes of ISDN were presented. The role of the CCITT, the key organization in the development of ISDN standards, was discussed. Political and technical issues at both international and national levels were summarized.

III. ISDN SERVICES AND TECHNOLOGIES

A. PURPOSE

The purpose of this chapter is to describe the various services of an ISDN. Background information on the technologies supporting the ISDN concept will also be discussed. A generalized framework of the Open Systems Interconnection (OSI) Reference Model and integrated digital networks is presented.

B. DESCRIPTION OF SERVICES

> "The ISDN, first of all, is not equipment. It is a capability for providing expanded and advanced services to customers. Equipment will have to be developed so that new communication services can be made available to a broad base of users." [Ref. 11: p. 45]

The existing, expanded, and advanced services may be broadly categorized as either voice or non-voice. Voice service is primarily telephone, with future services expanding to include information retrieval using voice recognition and speech synthesis. Non-voice services include digital data, text, and imagery. [Ref. 10: p. 544]

Examples of digital data services are telemetry, funds transfer, information retrieval, mailbox, electronic mail, alarms, and, at higher data rates, high-speed computer communication. [Ref. 10: p. 544] Although most of these services already exist, some, such as telemetry and alarms,

integrated digital network through the INS, the IDN phase in the evolution will be complete. The INS enhancements parallel those which would be expected in an IDN, as it evolves toward an ISDN. [Ref. 29: p. 68]

The services and terminal equipment interfaces for the Mitaka area are indicated along the left side of Figure 6-1, and those for the Tokyo section, along the bottom right. The offices designated by dotted boxes correspond to the "Central Offices" in Figure 5-1, and interconnect by matching the directional arrows. With the exception of the broadband section, indicated along the bottom of Figure 6-1, the box labeled "Existing Network" is the "Core Network" described in Chapter V. The users accessing the broadband services would comprise a special sub-network of the INS.

By envisioning a mirror-image of the Mitaka area portion of Figure 6-1, a correspondence with the configuration in Figure 5-1 could be obtained. The INS is utilizing the most modern technology to realize a "fully digitalized end-to-end connection...between subscriber equipment through the whole network." [Ref. 29: p. 68] NTT feels that this may be the first time such a system is operated as a public network "anywhere in the world." [Ref. 29: p. 68]

D. SUPPORT TECHNOLOGIES

The support technologies utilized in the INS model system include new techniques for terminal, switching, transmission, and broadband communications. The hardware

involved includes digital telephones with signal conversion circuitry, terminal control equipment, transmission and signaling information channels (B+D), videotex terminals, video terminals, and miscellaneous processors. [Ref. 29: p. 74]

E. COMPARISON WITH ISDN CONCEPTUAL FRAMEWORK

Standardization of equipment interfaces was independently determined by NTT, because the CCITT standards had not been agreed upon within the time frame necessary to commence INS configuration planning. Because of the relatively small-scale size of the pilot plant and the fact that equipment was centrally managed and provided by NTT, problems with standardization have been avoided. Upon completion of the model plan and after full-scale implementation is underway, problems with standardization may become more prevalent. [Ref. 30: p. 66]

The INS model system is based on established digital technologies and systems. As such, reliability should be within system design objectives. However, since the model plan has only been operational since September, 1984, performance history and activity statistics are not yet available. INS planners hope the model will provide "technical data and responses from users and maintenance personnel." [Ref. 30: p. 66]

Transparency requirements are the same as for ISDN. The user is insulated from the technical aspects of digital

transmission. There is no need or requirement for the user to be concerned with the transmission functions of the network; the only concern is that the particular desired service is available when needed.

An objective of the INS planners is to provide less expensive telecommunications. There is still some question, however, if, in fact, society really wants and will pay for the services an ISDN or INS, in particular, will provide. [Ref. 30: p. 64] In order to align price of services received with cost of services provided, the INS will incorporate a bit-rate tariff scheme. [Ref. 30: p. 66] This scheme follows the ISDN concepts of charging for capacity rather than connect time and insuring that one type of service does not subsidize the cost of providing another service. [Ref. 10: p. 543]

While the ISDN focus is on easy user access and compatibility, the INS "places more emphasis on usefulness to the user." [Ref. 30: p. 66] The variety of terminal services are designed for convenience of both the residential and commercial users.

Security features of INS have not been addressed in the available literature. It may be assumed, however, that sufficient security measures have been taken and are well supported through the use of digital end-to-end connectivity, as in ISDN.

Implementation of INS will follow a gradual process while maintaining existing telecommunications services. [Ref. 29: p. 68] The existing telephone network will be digitized gradually "on a replacement basis when the service life of existing facilities expires." [Ref. 31: p. 81] This parallels the ISDN plan for transition from IDN through ISDN-capable enhancements.

F. SUMMARY

NTT has devised an integrated digital telecommunications model system. This model system should provide valuable information as INS evolves toward a full-scale ISDN. Other ISDN planners will benefit from the lead taken by NTT in its development of INS.

VII. ISDN CONSIDERATIONS FOR DOD

A. INTRODUCTION

This chapter will present areas of consideration for ISDN development relating to non-tactical Department of Defense (DoD) communications. Discussion will be limited to general conceptual considerations without identification of specific applications.

The ISDN concept is being developed worldwide and represents the state-of-the-art technologies in digital transmission, switching, signaling, and network management. To avoid duplication of effort, it is important that the evolving ISDN developments be closely monitored for potential crossover DoD applications.

B. ISDN FEATURES APPLIED TO DOD

This section will present features of the ISDN conceptual framework as applied to DoD. The features discussed are standardization, reliability, transparency, economy, convenience, security, and transition.

The ISDN standardization objective that calls for a single set of ISDN standards to permit universal access and the development of cost effective equipment could prove beneficial to DoD. Standards supporting universal access offer worldwide interoperability and interconnectivity, which are features important for DoD operation. It is

important that the DoD maintain representation on the various standards committees during ISDN development so that requirements of the DoD are included.

Because of the improved technologies involved in transmitting digital vis-a-vis analog signals, a digital based system, such as ISDN, should prove more reliable over time. The DoD depends on reliable systems for survivability not only in times of conflict, but also for routine operations.

Transparency must be viewed from within the DoD from different perspectives. For most routine administrative communications, it is usually not necessary that the user understand the mechanics of the network. However, for the more sensitive communications which support mission operations, the 'black box' approach may not be as readily acceptable.

Currently, ISDN is being undertaken primarily by telephone companies worldwide. Significant amounts of time and money have been expended on research and development. The DoD could benefit from evolving ISDN technologies without necessitating duplication of development effort. It is likely that there will be many DoD applications to which commercially available products and services of ISDN may be adapted for use. Examples of these applications may include facsimile machines and digital voice services. To the extent that commercial technologies and services can satisfy

the specialized needs of the DoD, they should be appropriately considered as alternatives in procurement or in-house development decisions.

The convenience of an ISDN system is that many services are readily available for the user. Services such as voice, information transfer, and facsimile can be of immediate use to the DoD. In the opinion of the author, future developments such as teletex, videotex, and video teleconferencing should have promising DoD applications. As examples, many routine administrative functions could be expedited and some personnel travel could be eliminated.

In any DoD communications system, security is important. In a network such as ISDN which can be accessed by many different types of users, the specialized security needs of the DoD must be appropriately considered. Encryption of digitized signals can be accomplished at the digital interface, which may be a user terminal. The integrated voice/data capabilities of ISDN should provide a "faster, more comprehensive means of establishing secure connections separately from the [existing] talk-path which carries encrypted information." [Ref. 26: p. 2-28]

Any evolution toward ISDN should be gradual. Any large scale movement toward ISDN by the DoD would be subjected to the same Program Objective Memorandum (POM) and budget reviews as other major new program initiatives. There is a considerable amount of lead time involved in these reviews,

and program initiatives must compete for limited resources. Accordingly, it is important that any ISDN program initiatives have the top level support required to survive the POM and budget review cycles. A successful transition to ISDN would require an early commitment from top command levels.

In addition to the budget and procurement lead times involved in transition to ISDN, there would be additional lead time involved in installation of the new supporting technologies. The long lead time does provide the opportunity to effect an orderly transition. As an example, older equipment can be replaced as necessary with newer digital components, similar to NTT's program for the INS.

C. CONCEPTUAL MILITARY ISDN

To begin to envision an ISDN for the military, it is possible to accept an initial concept, then adapt it to the special requirements of the military. Aspects of some existing networks would merge nicely with some IDN or ISDN capabilities.

The Automatic Digital Network (AUTODIN) II has been replaced by the Defense Data Network, DDN, a system based on technology developed from the Advanced Research Projects Agency Network, ARPANET. The DDN is a "single, integrated packet switching network designed to meet the data communications requirements of the DoD." [Ref. 32: p. 5] The DDN is evolving in stages as a combination of several

other military networks, and began the process of implementation throughout the DoD in February, 1984. Plans call for the ability to transmit classified information on a sub-network of the DDN. [Ref. 32: p. 21]

The DDN is a visible, operational network which could be included as a "Service" or "Other Network" (sub-network) in the "Core Network" described in Figure 5-1. This could be the first step toward a DoD ISDN.

The DDN was designed solely for data transmission. A possible IDN enhancement would be development of a digital voice telephone to interface with the DDN. A form of 'digital pipe' theoretically exists for the DDN, which could be upgraded to include the voice services, such as enhancements or replacements for the commercial, Automated Voice Network, (AUTOVON), and Federal Telecommunications System (FTS) services now available. Another IDN or ISDN service immediately useful to the DoD is facsimile, which is currently operational, for example, in the INS model system, using digital broadband high speed terminals. [Ref. 30: p. 67]

The DDN terminals are standardized for the ARPANET, and would require adaptation to whatever ISDN standards are developed. There are many other features of the ISDN and IDN, mentioned in the previous section, that could prove beneficial for use in the DoD. Security, reliability, and economy are perhaps the most important features for a DoD

ISDN. Such a system should be evaluated as a viable alternative to the current plans for upgrade and replacement of the existing systems.

D. SUMMARY

The DoD can benefit greatly both from the evolving technologies supporting ISDN and from implementation of an ISDN. The DDN is an existing system which could be gradually enhanced to evolve into an IDN, and later, an ISDN.

Among the most important features of ISDN for the DoD are security, reliability, and economy. It is in the best interest of the DoD to remain abreast of ISDN developments as technologies improve and costs decrease as expected. ISDN's potential for improved worldwide connectivity and interoperability of communications systems, especially in times of conflict, makes it a viable system, worthy of careful consideration by DoD.

VIII. UNRESOLVED ISSUES AND SUMMARY

A. INTRODUCTION

The major unresolved issues surrounding ISDN pertain to standardization. Because ISDN is a global initiative, many different countries, committees, and groups are involved in its evolution. Also, the needs of equipment manufacturers, telecommunications vendors, and commercial and residential users must be considered. As a result, standardization has been a difficult objective to achieve.

Other ISDN issues addressed include economic and tariff considerations. These issues will be discussed only to the degree necessary to provide the reader with an awareness of their existence.

B. STANDARDIZATION ISSUES

As stated in Chapter II, a single set of ISDN standards is necessary for universal access and cost-effective equipment development. [Ref. 10: p. 540] The CCITT is continuing discussions on the issues of standardization. Among these issues are concerns about the location of the line of demarcation between the network and the user interface. The Federal Communications Commission (FCC) has ruled that the network termination 'box,' discussed in Chapter V, is part of the customer premises equipment and not part of the public network. This has placed the U.S. in

a position that is at variance with the CCITT draft recommendations which state that the 'box' is the network termination. It has been argued that the FCC ruling "will inhibit introduction of new services because it makes standards setting particularly difficult." [Ref. 20: p. 47] If standards cannot be reached, end-to-end network compatibility will suffer. The establishment of worldwide standards for ISDN will not be possible until this dispute is resolved.

Even with the open architecture planned for the ISDN, problems exist in pro-competitive environments, such as the United States. Among the objectives of the ISDN, as stated in Chapter II, is the U.S. requirement that "certain enhanced services be offered competitively." [Ref. 10: p. 540] Competition within the enhanced services should not interfere with the provision of the basic network services. Figures 8-1 and 8-2 contrast ISDN's in noncompetitive and competitive environments. [Ref. 10: pp. 541-2]

C. ECONOMIC AND TARIFF ISSUES

A basic economic question with ISDN is how it will pass the test of the marketplace. The test will ultimately be decided by the demand generated for ISDN services. There are substantial investment costs associated with the transition to digital technology. At issue will be whether the eventual market demand for ISDN will justify its investment costs.

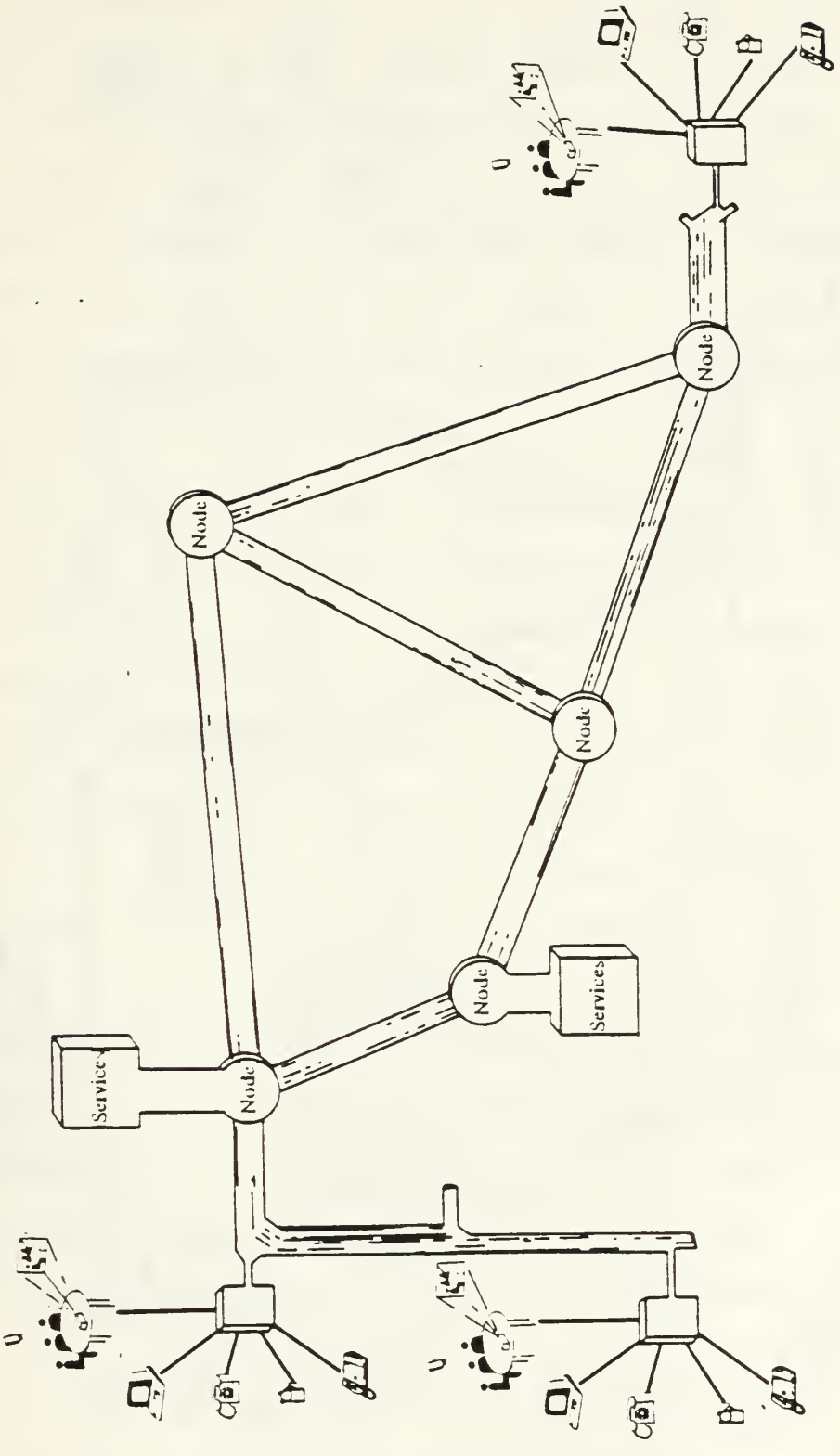

Figure 8-1 ISDN in a Noncompetitive Environment.

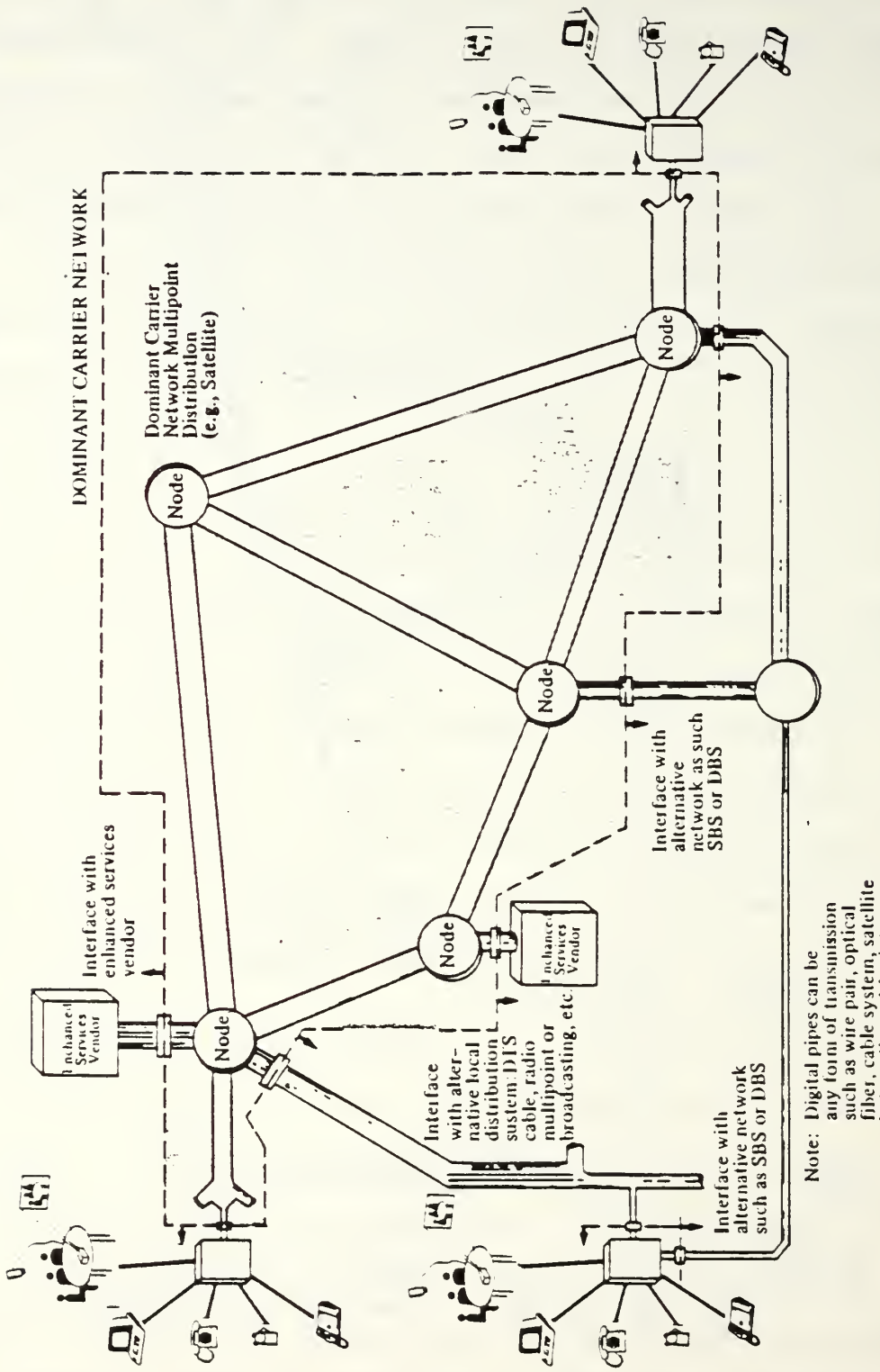

Figure 8-2 ISDN in a Competitive Environment.

It is presently unknown how tariffs will actually be assessed. Some advocates of ISDN support a bit-rate tariff, where the user charges are based on "capacity used rather than connect time." [Ref. 10: p. 540] The NTT INS plan, discussed in Chapter VI, eventually intends to incorporate a bit-rate pricing scheme in its network. The impact of bit-rate pricing for ISDN services has yet to be determined.

SUMMARY

There are no true ISDN's in operation today. Evolution toward ISDN as at different stages in different countries. Some countries, particularly Japan and Canada, have demonstrated a commitment to an evolution toward ISDN.

There are potential applications for ISDN within DoD. Primary benefits to the DoD of an ISDN include security, reliability, and economy. It is possible that an existing DoD system, the DDN, could be enhanced with IDN/ISDN features. Future long range plans of the DoD should include appropriate considerations for IDN and ISDN developments.

The future of ISDN will be heavily dependent upon the acceptance of universal standards. It is necessary for a consensus to be reached soon to permit carriers, manufacturers and users to adapt to the ISDN evolution.

LIST OF REFERENCES

1. Shivoder, Charles A. III, "Pie in the Sky?," On Communications, February 1985.

2. Stallings, William, "The Integrated Services Digital Network," Datamation, December 1, 1984.

3. U.S. Department of Commerce, National Telecommunications and Information Administration SP-83-15, International Telecommunications Standards: Issues and Implications for the '80's, by D.M. Cerni and E.M. Gray, May 1983.

4. American Telephone and Telegraph Advertisement, "Universal Information Services: An Integrated Network Architecture," Business Week, February 25, 1985.

5. Kostas, D.J., "Transition to ISDN - An Overview", IEEE Communications Magazine, Vol. 22, No. 1, January 1984.

6. Robin, G. and Treves, S.R., "An Introduction to Integrated Services Digital Networks", International Telephone and Telegraph Journal, Electrical Communication Volume 56, Number 1, 1981.

7. "Overview," International Telephone and Telegraph Journal, Electrical Communication, Volume 56, Number 1, 1981.

8. Tanenbaum, Andrew S., Computer Networks, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1981.

9. U.S. Department of Commerce, National Telecommunications and Information Administration Report 83-138, A Primer on Integrated Services Digital Networks (ISDN): Implications for Future Global Communications, ITS Staff, September 1983.

10. Stallings, William, Data and Computer Communications, Macmillan Publishing Company, New York, 1985.

11. Chen, R.K., "ISDN - The Network of the Future", Telecommunications, December 1983.

12. Smith, E.A., Walsh, W.A.G., Willson, M.J., "Impact of Non-Voice Services on Network Evolution," International

Telephone and Telegraph Journal, Electrical Communications, Volume 56, Number 1, 1981.

13. Martin, James, Telecommunications and the Computer, 2d ed., Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1976.

14. Rosner, Roy D., Packet Switching, Wadsworth, Inc., Lifetime Learning Publications, Belmont, California, 1982.

15. Vaughan, H.E., "Research Model for Time-Separation Integrated Communication," The Bell System Technical Journal, Volume XXXVIII, Number 4, July, 1959.

16. Weber, Jonathan, "PacBell Files for ISDN Patents," MIS Week, Vol. 6, No. 12, Wednesday, March 20, 1985.

17. "Users are Blase as Carriers and Vendors Wax Hot over ISDN," Newsfront Section, Data Communications, February, 1984.

18. Griffiths, John M., "ISDN Network Terminating Equipment," IEEE Transactions on Communications, Vol. Com-30, No. 9, September, 1982.

19. Terreault, R.C., "What Do ISDN Users Need?," Telephony, September 3, 1984.

20. McDonald, John C., "U.S. 'No' to ISDN Standards," Telephony, December 3, 1984.

21. National Telecommunications and Information Administration, Impact of ISDN Standardization on Interoperability, by J.A. Hull and D.V. Glen, Institute for Telecommunication Sciences, Boulder, Colorado, December, 1983.

22. Gannon, Thomas F. III, "The Communications Highway," Infosystems, June, 1984.

23. Rosenberg, Jerry M., Dictionary of Computers, Data Processing & Telecommunications, John Wiley & Sons, Inc., New York, New York, 1984.

24. Pooch, Udo W., Greene, William H., Moss, Gary G., Telecommunications and Networking, Little, Brown and Company, Boston, Massachusetts, 1983.

25. Gimpelson, L.A., Kimbleton, S.R., Wang, P.S.C., "Networking for Public and Private Network

Applications," IEEE International Conference on Communications, 1984.

26. GTE Products Corporation, Report 00-2725031, "ISDN/DCS Issues and Alternatives Final Report," Communications Systems Division, GTE Communications Products Corporation, Task Order 83-3, December 2, 1983.

27. Green, D.L., Cole, L.J., Phile, W.G., "Private Network Integrates Data, Voice, and Video Communications," Data Communications, May 1984.

28. Farrell, John H., "The Reality of ISDN," Telephony, July 9, 1984.

29. Kuwabara, Moriji, "Japan is Making INS a Reality," Telephony, October 24, 1983.

30. Myers, Del, "Japan's INS System Probes the Present for Clues to Future Services," Telephony, January 28, 1985.

31. Masuda, Etsuzo, "Japanese Telecommunications Takes on a Brand New Look," Telephony, January 28, 1985.

32. Defense Communications Agency, "Defense Data Network," undated brochure containing general information on the capabilities and characteristics of the DDN.

BIBLIOGRAPHY

Altman, June, "BOCs Eager To Carry Data," MIS Week, Vol. 6, No. 12, Wednesday, March 20, 1985.

Anderson, Kevin, "Megaduty Phone Line," USA Today, March 15, 1985.

Andrews, F.T., "ISDN '83," IEEE Communications Magazine, Vol. 22, No. 1, January 1984.

Bender, Warren G., "Is the ISDN a Future Fact or Current Fancy?" Telephony, February 21, 1983.

Bhusri, G.S., "Considerations for ISDN Planning and Implementation," IEEE Communications Magazine, Vol. 22, No. 1, January 1984.

Black, Uyless D., Data Communications, Networks, and Distributed Processing, Reston Publishing Co., Inc., Reston, Va., 1983.

Blake, R.K., "Global Telecommunications: A Strategy and a Commitment," Telecommunications, November 1984.

Block, Victor, "Telcom Canada to Link Conference 600 with U.S.," Telephony, November 19, 1984.

Cain, Marshall L., "Telecommunications Technology and Policy," term paper, Massachusetts Institute of Technology, December 14, 1983.

Collie, Brian E., Kayser, Larry S., and Rybczynski, Antony M., "Looking at the ISDN Interfaces: Issues and Answers," Data Communications, June 1983.

Decina, Maurizio, "CCITT Recommendations on the ISDN: A Review," Telephony, December 3, 1984.

_____. "Managing ISDN Through International Standards Activities," IEEE Communications Magazine, Vol. 20, No. 9, September 1982.

_____. "Progress Towards User Access Arrangements in Integrated Services Digital Networks," IEEE Transactions on Communications, Vol. Com-30, No. 9, September 1982.

Dorros, Irwin, "ISDN," IEEE Communications Magazine, Vol. 19, No. 3, March 1981.

_____. "Shaping the ISDN: The Public Network's Role," Telephony, October 24, 1983.

_____. "Telephone Nets Go Digital," IEEE Spectrum, Vol. 20, No. 4, April 1983.

Gerard, Allan, "Business Applications for U.S. Digital Networks," Telephony, February 6, 1984.

Gerla, Mario and Pazos-Rangel, Rodolfo A., "Bandwidth Allocation and Routing in ISDN's," IEEE Communications Magazine, Vol. 22, No. 2, February 1984.

Harish, Suri, Data Communications, Alfred Publishing Co, Inc., Sherman Oaks, CA, 1983

Hershkowitz, Harvey S., "Will ISDN Prove Perilous for Users?" MIS Week, Vol. 6, No. 10, Wednesday, March 6, 1985.

Kaderali, F. and Weston, J.D., "Digital Subscriber Loops," International Telephone and Telegraph Journal, Electrical Communication, Vol. 56, Number 1, 1981.

Kaplan, Gadi, "Japan's Information Network System," IEEE Spectrum, Vol. 21, No. 5, May 1984.

Kuwabara, Moriji, "Japan Tests Its Model Communications System," IEEE Spectrum, Vol. 21, No. 5, May 1984.

Lewin, Leonard, ed., Telecommunications: An Interdisciplinary Text, Artech House, Inc., Dedham, MA, 1984.

Littlechild, S.C., Elements of Telecommunications Economics, The Institution of Electrical Engineers, London, 1979.

Martin, James, Design and Strategy for Distributed Data Processing, Prentice-Hall, 1981.

Medina, Hector, "Upgrade vs. Replacement: Studying the Possibilities," Telephony, January 7, 1985.

Najafi, Hamid, "Techniques for Implementation of ISDN Terminals," IEEE Conference on Communications, Elsevier Science Publishers B.V. (North-Holland), 1984.

National Communications System, FY 84-88 Program Plan for the Federal Telecommunication Standards Program, June 1984.

National Communications System Technical Information Bulletin 83-2, Relevance of National and International Telecommunication Standardization Activities to National Communications System Objectives, by John Gurzick, Bruce Fletcher, and Bruce Strackbein, April 1983.

National Communications System Technical Information Bulletin 83-3, CCITT Study Groups XI and XVIII Draft Recommendations for ISDN November 8 - December 2, 1983, by Frank M. McClelland and Janet M. Orndorff, December 1983.

Orbell, Arthur G., "British Telecoms Plans for ISDN," IEEE Conference on Communications, Elsevier Science Publishers B.V. (North-Holland), 1984.

Pernin, Jean-Louis, Randall, Theron M., and Schwartz, Arthur J., "Integrating Subscribers Into Evolving Digital Networks," IEEE Conference on Communications, Elsevier Science Publishers B.V. (North-Holland), 1984.

Pokress, Robert L., "Guest Editorial," IEEE Communications Magazine, Vol. 22, No. 1, January 1984.

Randall, Theron, "Evolving Toward a True ISDN," Telephony, February 11, 1985.

Roden, Martin S., Analog and Digital Communication Systems, Prentice-Hall, 1979.

_____. Digital and Data Communication Systems, Prentice-Hall, 1982.

Shimasaki, Nobuhiko and Takeshige, Yukio, "A Study on Multiple Mode Business Information Service Networks," IEEE Conference on Communications, Elsevier Science Publishers B.V. (North-Holland), 1984.

Simpson, Don, "Integrated Services Digital Network," presentation at IEEE Central California meeting, Stanford University, January 30, 1985.

Slatter, R.C., and others, "Customer Access to Integrated Services Digital Networks," International Telephone and Telegraph Journal, Electrical Communication, Vol. 56, Number 1, 1981.

Spiers, Ian, Winch, Nicholas R., and Lane, Charles H., "Integration of Public and Private Networks," IEEE Transactions on Communications, Vol. Com-30, No. 9, September 1982.

Termote, A., and others, "ISDN Field Trial in the Belgian Network," IEEE Conference on Communications, Elsevier Science Publishers B.V. (North-Holland), 1984.

Tolusso, G. and Treves, S.R., "Application of Distributed Control to Handling Non-Voice Services," International Telephone and Telegraph Journal, Electrical Communication, Vol. 56, Number 1, 1981.

Waber, Kurt W., "Considerations on Customer Access to the ISDN," IEEE Transactions on Communications, Vol. Com-30. No. 9, September 1982.

Wienski, R.M., "Evolution to ISDN Within the Bell Operating Companies," IEEE Communications Magazine, Vol. 22, No. 1, January 1984.

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